is 3.5 coulombs. Ten breakings would thus produce 35 coulombs, the average amount required for an average lightning flash, again a reasonable result. Thus the proposed theory is in conformity with the facts and the amount of breaking of drops and the quantities of electricity involved are not out of harmony with what might be expected from observed facts.

The three possible types of lightning discharge are denoted as follows:

(1) Discharge from the seat of positive charge upward into the cloud—type U.

(2) Discharges downward from the same region—type D. These may be further subdivided into types D_1 and D_2, according as to whether the discharge reaches the ground or not.

(3) Discharges from the ground up to the negatively charged cloud—type N.

Schonland and Craib, from their observations of storms and the field changes resulting upon the lightning discharges, arrived at conclusions which they thought to be definitely inimical to the breaking drop theory. Doctor Simpson reexamines their results and finds that the discrepancy is due to the fact that Schonland and Craib ignored the possibility of a lightning flash directed downward toward the ground, but failing to reach the ground (*i. e.*, type D_2). Taking this important point into consideration, it is shown that the results of Schonland and Craib and Wilson fit excellently with the present theory.—*C. E. Britton.*

THE CARACOLES METEOROLOGICAL STATION AND ITS IMPORTANCE FOR THE TRAFFIC OF THE TRANSANDINE RAILWAY AND AVIATION

By JULIO BUSTOS NAVARRETE, Director

[Observatorio del Salto, and professor in the aviation school, Santiago de Chile, May, 1928]

The great storms that frequently blow, year after year, over the Andes Mountains have not been properly studied, and all the observations available, as force of the wind; nebulosity; amount of clouds, forms, velocity, and direction; visibility; height of snow; rainfall and hydrometeors, where only dispersed observations were made by different persons. The need for scientific data about the storms over the Andes Mountains has been clearer since Transandine Railway and aviation require to be in possession of reliable facts about the weather, not only for the development of their traffic but also before crossing over on each passage.

At the beginning of the year a letter was written from the Observatorio del Salto to the manager of the Transandine Railway Co. asking them for their cooperation in the installation of a meteorological station in Caracoles. As the railway company is the most affected by the storms on the cordillera, our solicitude was favorably acknowledged and the necessary instruments for the installation were immediately bought.

The Caracoles meteorological station was finally installed on the 15th of May; and by its instruments as well as by its position it is called to provide observations of great interest. The meteorological shed or pavilion is located near the Caracoles Railway station and it is formed by double-latticed sides to prevent the snow from getting in, and it is also 4 meters from the ground, to prevent it being covered by the great snowstorms. Inside there is a Lambrech meteorograph apparatus of high precision, which was previously controlled by comparing it with the standard instruments of the Observatorio del Salto. This apparatus gives a continuous record of the pressure, temperature, and humidity. The pluviometer is located at a certain distance away from the railway station and the vane is on the station itself.

The following observations are made daily and transmitted by telegraph to the Observatorio del Salto: Atmospheric pressure, reduced to sea level; relative humidity; temperature of the air, maxima and minima; wind's direction and force; clouds, amount, forms, velocity, and direction; visibility; height of snow; rainfall; hydrometeors.

It remains for us to say that the Caracoles meteorological station is situated on the highest point of the Transandine Railway, near the Cumbre, and at the side of the entrance to the international tunnel that joins Chile with the Argentine Republic. The station is approximately at 3,200 meters altitude.

The first diagrams received from the registering apparatus of the Caracoles meteorological station immediately revealed certain peculiarities of remarkable interest; the oscillations of the atmospheric pressure are not simultaneous with those of the central zone of Chile; they produce themselves 24 hours later, and seem to be intermediate with those of the Argentine Republic; the oscillations of the temperature exceed the values which had been estimated for them before. For example, on the week from the 14th to the 21st of May, minima of 15° C. below zero were registered, etc.

In our monthly bulletin we will publish a résumé of the meteorological observations of the Caracoles station, which, as before stated, is situated on the limit of two meteorological systems or régimes; these observations will be very important for the proper study of the meteorological conditions in Chile and in the Argentine Republic. In Chile we have a system of winter rains and storms, while in the Argentine Republic they have a system of summer rains and storms.

All storms are produced in Chile by depressions coming from the Pacific Ocean, and in consequence with a falling barometer; while over in the Argentine all storms are produced when an anticyclonic area advances from the south, with the existence of a relative depression over the north central part of the country; in consequence, they are produced with a high barometer.

The most severe storms over the Chilean side very rarely reach any farther than Tierra Amarilla, and the most intense Argentine storms scarcely come any farther this way than Juncal. The greater part of the water vapor condenses and precipitates itself over the cordillera.

Serious doubts have risen regarding the displacements of the depressions. Not long ago, it was discussed, if the depressions that come from the Pacific Ocean, that affect Chile's central zone, could really cross over the cordillera, and influence the weather over Argentine's central zone; nevertheless, the Caracoles observations seem to infer that certain depressions coming from the Pacific Ocean occasionally manifest themselves 24 hours later over the cordillera and afterwards over Argentine's central zone.

Finally, this will be a matter of future investigations, as we are not able yet to advance any further on the subject.

Meanwhile the Caracoles observations, together with those of Los Andes and Mendoza, are very valuable and useful. Complete meteorological information and a weather forecast for the subsequent 24 hours are sent daily by cable to the manager of the Transandine Railway. These data are very useful for the Transandine traffic and transportation of cargo.

The Latecoere Commercial Aviation Co. has also taken an interest in our Andes Mountains meteorological studies, and, if it is necessary, they are willing to install a new observatory in the interior of the cordillera, farther north, opposite the town of Copiapo. The development of commercial aviation is intimately dependent for its success upon a good service of meteorological information about the weather over the cordillera, thus preventing loss of material and irreparable accidents or disaster.

HAILSTONES OF GREAT SIZE AT POTTER, NEBR.

By THOMAS A. BLAIR

[Weather Bureau Office, Lincoln, Nebr., August 22, 1928]

A remarkable hailstorm occured at Potter, Cheyenne County, Nebr. (lat., 41° 13′ N.; long., 103° 18′ W.; elevation, 4,387 feet), on July 6, 1928, during which hailstones "as large as grapefruit" fell, one of which measured 17 inches in circumference and weighed 1½ pounds. This appears to be the largest single hailstone of which there is authentic record anywhere in the world. The largest I have found described elsewhere are by Russell, [1] who tells of a hailstorm in New South Wales in which "some of the stones were said to be 14 inches in circumference," and of three storms in India in which stones measured from 10 to 12 inches.

The following account is given by Mr. H. Stevens, cooperative observer of the Weather Bureau at Potter since 1921 and editor of the weekly newspaper, the Potter Review, in which the article was published, July 13, 1928:

People of Potter and the immediate community will recall the hailstorm of July 6, 1928, for many years to come and will have their narrations of the event disputed on every score. A dark cloud approached from the west and gave the appearance of containing considerable wind. Most people were out watching the progress of the storm, when a peculiar hissing noise was heard in the air and hailstones as large as baseballs began falling at various distances. The hailstones soon increased in size and some were as large as grapefruit, most of them almost round and measuring from 10 to 14 inches in circumference, and weighing from 10 ounces to a pound and a half.

This particular display of the ethereal iceman seemed to center in Potter, the community reporting a slight fall of smaller hailstones. No particular damage was done by this record-breaking hail, except a few roofs were slightly injured, four houses and a garage reporting holes torn through the roof by the gigantic but widely scattered hailstones. We would estimate that about 10 stones fell on each space the size of an ordinary town lot. They fell from 10 to 15 feet apart. The monster chunks of ice could be heard hissing through the air, and when they hit in plowed or soft ground completely buried themselves, and sank halfway in on prairie ground.

In a letter confirming this statement Mr. Stevens gave the following additional description of the appearance of these stones:

The stones, most of which measured around 14 inches in circumference, were smooth, of clear ice, and made up of concentric rings around a single center. Some stones were jagged, having the appearance of one large stone with a number of little stones frozen on its outside.

The following affidavits were kindly obtained by Mr. Stevens from two responsible and conservative citizens of Potter:

POTTER, NEBR., *August 11, 1928.*

To whom it may concern:

I, J. J. Norcross, proprietor of the Potter Drug Co., do affirm the following facts:

That on July 6, 1928, following the hailstorm in Potter, Nebr., I gathered several hailstones and measured and weighed them on standard store scales, and that one stone measured 17 inches in circumference and that it weighted 1½ pounds; and that I found another one almost twice as large but was evidently composed of two mammoth stones frozen together. The 17-inch stone was round and hard, with smooth surface, and upon breaking it open I found it was composed of concentric layers built around one center.

(Signed) J. J. NORCROSS.

Subscribed and sworn to before me this 13th day of August, 1928.

[SEAL]. A. J. AMES, *Notary Public.*

POTTER, NEBR., *August 11, 1928.*

To whom it may concern:

I, Andrew Anderson, a resident of Potter, Nebr., do affirm that on July 6, 1928, I picked up hailstones in Potter, Nebr., and that one round smooth stone weighed 19 ounces and was 15 inches in circumference. The stone had been outside 10 or 15 minutes before I picked it up, and perhaps had already melted some. Another stone, measured 7 inches from tip to tip, was 4½ inches in diameter at the largest point and about 3 inches in diameter at the small end. From appearances this stone was only a part of a larger stone, it being broken. I would judge the whole stone, if it were intact, the pieces of which were lying around close by, would have been as large as an average man's head.

(Signed) ANDREW ANDERSON.

Subscribed and sworn to before me this 13th day of August, 1928.

[SEAL.] A. J. AMES, *Notary Public.*

The photograph was taken by Mr. Norcross with the stones resting on 10-ounce glass tumblers, such as are used in soda-fountain service. The stone on the extreme right is that described by Mr. Norcross which measured 17 inches in circumference and weighed 1½ pounds, and that on the extreme left is the one he described as two mammoth stones frozen together. It will be noted that several of the stones, including the 17-inch one, are described as round and smooth, of clear ice, and were found to consist of concentric layers around a single center, showing that they were built up as single stones and not as agglomerations of smaller ones.

The explanation commonly given of the formation of hail assumes that the size of the hailstones is limited by the strength of the upward convection current. This explanation appears insufficient to account for stones of the size of those reported here. No convective updraft would support stones approaching these in size. The fact seems to be generally overlooked that hailstones may grow rapidly while falling. These immense stones probably began to fall when of ordinary diameter but fell through a thick stratum of super-cooled droplets. As they fell they grew with great rapidity by contact with these droplets, which instantly congealed upon them

[1] In the book, On Hail, pp. 50 to 62, by R. Russell, published by Edward Stanford, London, 1893.